Notice No. 2 Corrigenda

Rules and Regulations for the Classification of Offshore Units, July 2014

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Issue date: February 2015

Amendments to	Effective date
Part 11, Chapter 1	CORRIGENDA
Part 11, Chapter 2	CORRIGENDA
Part 11, Chapter 4	CORRIGENDA
Part 11, Chapter 5	CORRIGENDA
Part 11, Chapter 11	CORRIGENDA
Part 11, Chapter 13	CORRIGENDA
Part 11, Chapter 18	CORRIGENDA

Lloyd's Register

This Notice reflects the corrigenda associated with underlining throughout Part 11 (no other formatting has been applied to show changes).

It should be read in conjunction with Notice No 1 to 2014 Rules for Offshore Units which details the editorial and typographical Corrigenda items.

Part 11, Chapter 1

General

Guide to the reader

Where IGC Code content has been modified in order for application to ship units engaged in the production, storage and offloading of liquefied gases at a fixed location, the revised text is shown underlined. Where paragraphs, Figures and Tables have been taken from the IGC Code and renumbered, the modified number(s) are shown underlined, e.g., 1.2.3.

1.1 Application

1.1.1 Flammable liquids having a flashpoint of 60°C (closed-cup test) or less and the flammable products listed in Chapter 19 shall not be carried in tanks located within the protective zones described in 2.4.1, within the longitudinal extent of the hold spaces for those tanks.

(*Part only shown*)
1.1.2 Where a risk assessment or study of similar intent is utilised within this Part, the results shall also include, but not be limited to, the following as evidence of effectiveness:

1.2 Definitions

Except where expressly provided otherwise, the following definitions apply to this Part. Additional definitions are provided in Chapters throughout this Part.

1.2.3 Boiling point is the temperature at which a product exhibits a vapour pressure equal to the atmospheric pressure.

1.2.4 Breadth, B, in metres, means the maximum breadth of the ship unit, measured amidships to the moulded line of the frame.

1.2.5 Cargo area is that part of the ship unit which contains the cargo containment system and cargo pump and compressor rooms and includes the deck areas over the full length and breadth of the part of the ship unit over these spaces. Where fitted, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are excluded from the cargo area.

1.2.6 Cargo containment system is the arrangement for containment of cargo including, where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the hold space.

1.2.7 Cargo control room is a space used in the control of cargo handling operations.

1.2.8 Cargoes are products, listed in Chapter 19, that are carried in bulk by ship units subject to the requirements of this Part.

1.2.9 Cargo machinery spaces are the spaces where cargo compressors or pumps, cargo processing units, are located, including those supplying gas fuel to the engine room.

1.2.10 Cargo pumps are pumps used for the transfer of liquid cargo, including main pumps, booster pumps, spray pumps, etc.

1.2.11 Cargo service spaces are spaces within the cargo area used for workshops, lockers and storerooms that are of more than 2 m^2 in area.

1.2.12 Cargo tank is the liquid-tight shell designed to be the primary container of the cargo and includes all such containment systems whether or not they are associated with the insulation or/and the secondary barriers.

1.2.13 Closed loop sampling is a cargo sampling system that minimises the escape of cargo vapour to the atmosphere by returning product to the cargo tank during sampling.

1.2.14 Cofferdam is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

1.2.15 Control stations are those spaces in which the ship unit's radio or emergency source of power is located, or where the fire recording or fire control equipment is centralised. This does not include special fire control equipment, which can be most practically located in the cargo area.

1.2.16 Flammability limits are the conditions defining the state of fuel oxidant mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.

1.2.17 Flammable products are those identified by an 'F' in column 'f' in the Table in Chapter 19.

1.2.18 FSS Code is the Fire Safety Systems Code meaning the *International Code for Fire Safety Systems* as adopted by the Maritime Safety Committee of the Organisation by Resolution MSC.98(73), as amended.

1.2.19 Gas carrier is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products listed in Chapter 19 of the IGC Code.

1.2.20 Gas Combustion Unit (GCU) is a means of disposing of excess cargo vapour by thermal oxidation, *see also* 1.2.49.

1.2.21 Gas consumer is any unit within the vessel using cargo vapour as a fuel.

1.2.22 Hazardous area is an area in which an explosive gas atmosphere is, or may be expected to be present, in quantities that require special precautions for the construction, installation and use of electrical equipment. When a gas atmosphere is present the following hazards may also be present: toxicity, asphyxiation, corrosiveness, reactivity and low temperature; these hazards shall also be taken into account and additional precautions for the ventilation of spaces and protection of the crew will need to be considered.

1.2.23 Hold space is the space enclosed by the structure of the ship unit in which a cargo containment system is situated.

1.2.24 IBC Code means the *International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk* adopted by the Maritime Safety Committee of the Organisation by Resolution MSC.4(48), as amended.

1.2.25 Independent means that a piping or venting system, for example, is in no way connected to another system and that there are no provisions available for the potential connection to other systems.

1.2.26 Insulation space is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

1.2.27 Interbarrier space is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

1.2.28 Length, *L*, in metres, is the length as defined in the *International Convention on Load Lines*.

1.2.29 Machinery spaces are all machinery spaces of category A and all other spaces containing propelling machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilising, ventilation and air conditioning machinery, and similar spaces and the trunks to such spaces.

1.2.30 Machinery spaces of category A are those spaces, and trunks to those spaces, which contain:

- .1 internal combustion machinery used for main propulsion for self-propelled units; or
- .2 internal combustion machinery used for purposes where such machinery has in the aggregate a total power output of not less than 375 kW; or
- .3 any oil-fired boiler or oil fuel unit or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

1.2.31 MARPOL means the *International Convention for the Prevention of Pollution from Ships*, 1973, as modified by the Protocol of 1978 relating thereto, as amended.

1.2.32 MARVS is the maximum allowable relief valve setting of a cargo tank (gauge pressure).

1.2.33 Non-hazardous area is an area other than a hazardous area.

1.2.34 Oil fuel unit is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a pressure of more than 1,8 bar gauge.

1.2.35 Organisation is the International Maritime Organization (IMO).

1.2.36 Permeability of a space means the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

1.2.37 Primary barrier is the inner element designed to contain the cargo when the cargo containment system includes two boundaries.

1.2.38 Products is the collective term used to cover the list of gases indicated in Chapter 19 of this Part.

1.2.39 Public spaces are those portions of the accommodation that are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.2.40 Recognised Organisation is an Organisation authorised by an Administration in accordance with IMO Resolution A.739(18) *Guidelines for the Authorisation of Organisations acting on Behalf of the Administration*, to act on their behalf to survey, certificate and determine tonnages as required by SOLAS, MARPOL and the Load Line Conventions.

1.2.41 Recognised standards are applicable international or national Standards acceptable to LR.

1.2.42 Relative density is the ratio of the mass of a volume of a product to the mass of an equal volume of fresh water.

1.2.43 Secondary barrier is the liquid-resisting outer element of a cargo containment system, designed to afford temporary containment of any envisaged leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the structure of the ship unit to an unsafe level. Types of secondary barrier are more fully defined in Chapter 4.

1.2.44 Separate systems are those cargo piping and vent systems that are not permanently connected to each other.

1.2.45 Service spaces are those used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.2.46 SOLAS Convention means the *International Convention for the Safety of Life at Sea*, 1974, as amended.

1.2.47 Tank cover is the protective structure intended either to protect the cargo containment system against damage where it protrudes through the weather deck or to ensure the continuity and integrity of the deck structure.

1.2.48 Tank dome is the upward extension of a portion of a cargo tank. In the case of below deck cargo containment systems, the tank dome protrudes through the weather deck or through a tank cover.

1.2.49 Thermal oxidation method means a system where the boil-off vapours are utilised as fuel for shipboard use or as a waste heat system, subject to the provisions of Chapter 16 or a system not using the gas as fuel complying with this Part.

1.2.50 Turret compartments are those spaces and trunks that contain equipment and machinery for retrieval and release of the disconnectable turret mooring system, high pressure hydraulic operating systems, fire protection arrangements and cargo transfer valves.

1.2.51 Vapour pressure is the equilibrium pressure of the saturated vapour above the liquid, expressed in bars absolute at a specified temperature.

1.2.52 Void space is an enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, oil fuel tank, cargo pumps or compressor room, or any space in normal use by personnel.

Part 11, Chapter 2

Ship Survival Capability and Location of Cargo Tanks

2.1 General

2.1.1 Ship units shall survive the hydrostatic effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship unit and the environment, the cargo tanks shall be protected from penetration in the case of minor damage to the ship unit resulting, for example, from contact with a shuttle tanker, offshore support vessel or tug, by locating them at specified minimum distances inboard from the shell plating of the ship unit. Both the damage to be assumed and the proximity of the tanks to the ~~shell of the~~ shell of the ship unit should be dependent upon the degree of hazard presented by the product to be carried. In addition, the proximity of the cargo tanks to the shell of the ship unit shall be dependent upon the volume of the cargo tank.

2.2 Freeboard and stability

2.2.1 Ship units subject to this Part may be assigned the minimum freeboard permitted by the International Convention on Load Lines in force. However, the draught associated with the assignment shall not be greater than the maximum draught otherwise permitted these Rules.

2.2.2 The stability of the ship unit, in all sea-going conditions including inspection/maintenance, ballasting and during loading and unloading cargo, shall comply with the requirements of the *International Code on Intact Stability*.

2.2.5 The Operator of the ship unit shall be supplied with a loading and stability information booklet. This booklet shall contain details of typical service and inspection/maintenance conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the survival capabilities of the ship unit. In addition, the booklet shall contain sufficient information to enable the Operator to load and operate the ship ~~unit~~ unit in a safe and seaworthy manner. *See also* Pt 1, Ch 2 and Pt 10, Ch 3,1.2.
In addition, the Operator is to be given an approved stability instrument to assess the intact stability and the damage stability condition according to the standard damage cases and the actual damage condition of the ship unit. The stability instrument input data and output results have to be approved by the Administration.

2.4 Location of cargo tanks

(Part only shown)
2.4.1 Cargo tanks shall be located at the following distances inboard:
Type 2G ship unit: from the moulded line of the bottom shell at centreline not less than the vertical extent of damage specified in 2.3 in Table 2.3.1 and nowhere less than '*d*' (see Figs. 2.2 and 2.3), where '*d*' is as follows:

2.4.2 For the purpose of tank location, the vertical extent of bottom damage shall be measured to the inner bottom when membrane or semi membrane tanks are used, otherwise to the bottom of the cargo tanks. The transverse extent of side damage shall be measured to the longitudinal bulkhead when membrane or semi membrane tanks are used, otherwise to the side of the cargo tanks. The distances indicated in 2.3 and 2.4 shall be applied as in Figs. 2.1(a) to (e).These distances shall be measured plate to plate, from the moulded line to the moulded line, excluding insulation

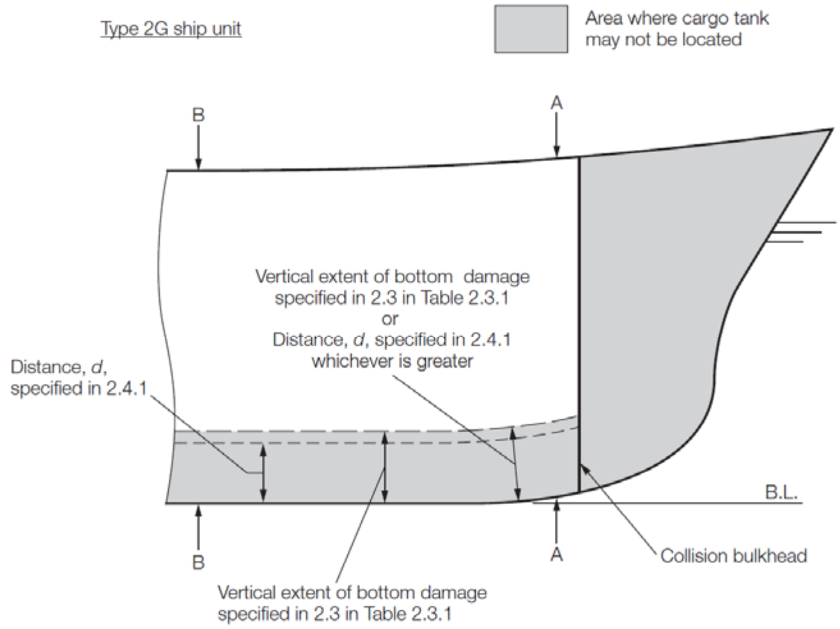


Fig. 2.2 Cargo tank location requirements, centreline profile, Type 2G ship units

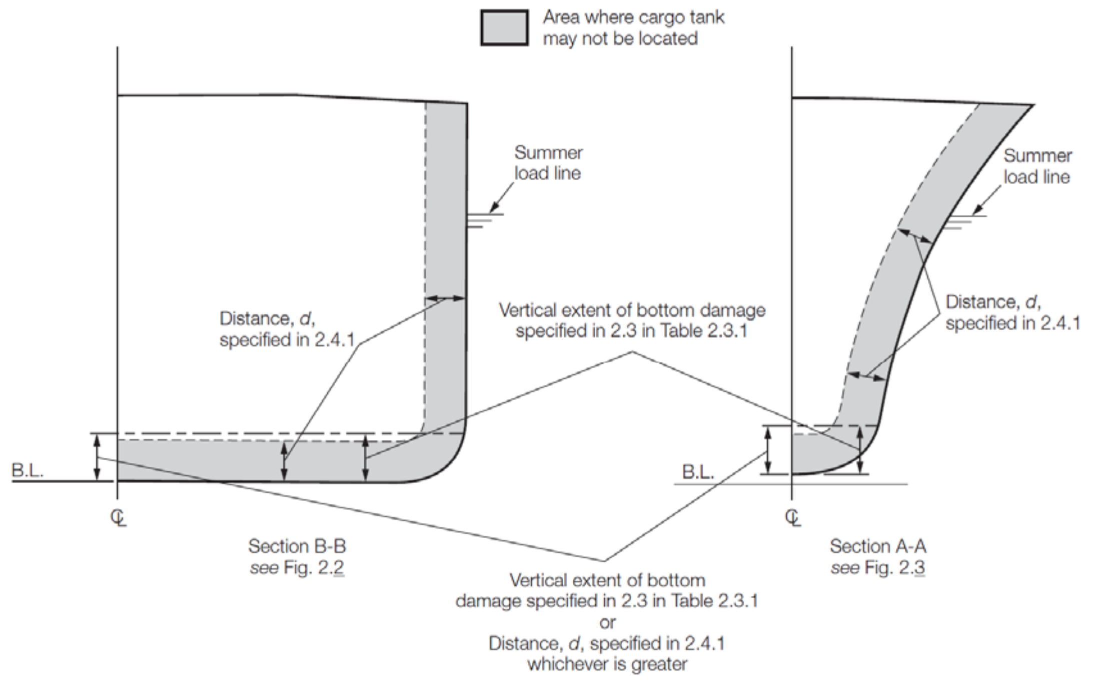


Fig. 2.3 Cargo tank location requirements, transverse sections, Type 2G ship units

2.5 Flood assumptions

2.5.1. The requirements of 2.7 shall be confirmed by calculations that take into consideration the design characteristics of the ship unit, the arrangements, configuration and contents of the damaged compartments, the distribution, relative densities and the free surface effects of liquids and the draught and trim for all conditions of loading.

2.5.4 The ship unit shall be designed to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.

2.5.5 Equalisation arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, shall not be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 2.7.1 and sufficient residual stability shall be maintained during all stages where equalisation is used. Spaces linked by ducts of large cross-sectional area may be considered to be common.

2.5.6 If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2.3, arrangements shall be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

(*Part only shown*)
2.5.7 The buoyancy of any superstructure directly above the side damage shall be disregarded. However, the unflooded parts of superstructures beyond the extent of damage may be taken into consideration provided that:

2.6 Standard of damage

2.6.1 Type 2G ship units shall be capable of surviving the damage indicated in 2.3 anywhere in its length with the flooding assumptions in 2.5.

2.7 Survival requirements

Ship units shall be capable of surviving the assumed damage specified in 2.3, to the standard provided in 2.6, in a condition of stable equilibrium and shall satisfy the following criteria.

Part 11, Chapter 4

Cargo Containment

4.1 Definitions

4.1.3 **Design temperature**. The design temperature for selection of materials is the minimum temperature for selection of materials is the minimum temperature at which cargo may be loaded or stored in the cargo tanks.

4.1.4 **Independent tanks** are self-supporting; they do not form part of the hull of the ship unit and are not essential to the hull strength. There are three categories of independent tank, which are referred to in 4.21, 4.22 and 4.23.

4.1.8 In addition to the definitions in 1.2, the definitions given in this Chapter shall apply throughout this Part.

4.3 Functional requirements

4.3.1 The design life of the cargo containment system shall not be less than the design life of the ship unit.

4.3.3 Cargo containment systems shall be designed with suitable safety margins:

.1 to withstand, in the intact condition, the environmental conditions anticipated for the cargo containment system's design life and the loading conditions appropriate for them, which include loads derived for the following scenarios: on-sit operation, inspection/maintenance, transit/ disconnect and accidental. The most onerous loading conditions are to be considered.

.2 that are appropriate for uncertainties in loads, structural modelling, fatigue, corrosion, thermal effects, material variability, ageing and construction tolerances.

4.3.4 The cargo containment system structural strength shall be assessed against failure modes, including but not limited to plastic deformation, buckling, and fatigue. The specific design conditions that should be considered for the design of each cargo containment system are given in 4.21 to 4.26. There are three main categories of design conditions:

.1 **Ultimate design conditions** – The cargo containment system structure and its structural components shall withstand loads liable to occur during its construction, testing and anticipated use in service, without loss of structural integrity. The design shall take into account proper combinations of the following loads:

- Internal pressure.
- External pressure.
- Dynamic loads due to the motion of the ship unit.
- Thermal loads.
- Sloshing loads.
- Loads corresponding to deflections of the ship unit.
- Tank and cargo weight with the corresponding reaction in way of supports.
- Insulation weight.
- Loads in way of towers and other attachments.
- Test loads.
- 10 000 year return period loading (this requirement may be waived where it can be proven that it is not appropriate, on a site-specific basis).

.2 **Fatigue design conditions** – The cargo containment system structure and its structural components shall not fail under accumulated cyclic loading.

.3 **Accident design conditions** – The cargo containment system shall provide the indicated response to each of the following accident conditions (accidental or abnormal events), addressed in this Part:

- Fire – The cargo containment systems shall sustain without rupture the rise in internal pressure specified in 8.4.1 under the fire scenarios envisaged therein.
- Flooded compartment causing buoyancy on tank – The anti-flotation arrangements shall sustain the upward force, specified in 4.15.1 and there should be no endangering plastic deformation to the hull.

4.3.5 Measures shall be applied to ensure that scantlings required meet the structural strength provisions and will be maintained throughout the design life. Measures include, but are not limited to, material selection, coatings, corrosion additions, cathodic protection and inerting.
Corrosion allowance need not be required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control, such as inerting around the cargo tank, or where the cargo is of a corrosive nature, LR may require a suitable corrosion allowance.

4.3.6 An inspection/survey plan for the cargo containment system shall be developed and approved at the time of build. The inspection/survey plan shall identify areas that need inspection during surveys throughout the cargo containment system's life and in particular all necessary in-service survey and maintenance that was assumed when selecting cargo containment system design parameters. Cargo containment systems shall be designed, constructed and equipped to provide adequate means of access to areas that need inspection as specified in the inspection/survey plan. Cargo containment systems, including all associated internal equipment shall be designed and built to ensure safety during operations, inspection and maintenance (*see* 3.5).

4.4 Cargo containment safety principles

4.4.1 The containment systems shall be provided with a full secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, of preventing lowering of the temperature of the structure of the ship unit to an unsafe level.

4.6 Design of secondary barriers

(Part only shown)

4.6.2 The design of the secondary barrier shall be such that:

.1 it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different project-specific requirements apply, taking into account the load spectrum referred to in 4.18.2.6. Project-specific requirements are to be submitted for consideration.

.2 physical, mechanical, or operational events within the cargo tank that could cause failure of the primary barrier shall not impair the due function of the secondary barrier, or vice versa.

.3 failure of a support or an attachment to the hull structure will not lead to loss of liquid tightness of both the primary and secondary barriers.

.4 it is capable of being periodically checked for its effectiveness by means acceptable to LR of a visual inspection or a pressure/vacuum test or other suitable means carried out according to a documented procedure agreed with LR.

.5 The methods required in 4.6.2.4 shall be approved by LR and shall include, where applicable to the test procedure:

4.8 Supporting arrangement

4.8.2 Anti-flotation arrangements shall be provided for independent tanks and be capable of withstanding the loads defined in 4.15.1 without plastic deformation likely to endanger the hull structure.

4.9 Associated structure and equipment

4.9.1 Cargo containment systems are to be designed for the loads imposed by associated structure and equipment. This includes pump towers, cargo domes, cargo pumps and piping, stripping pumps and piping, inert gas piping, access hatches, ladders, piping penetrations, liquid level gauges, independent level alarm gauges, spray nozzles, and instrumentation systems (such as pressure, temperature and strain gauges).

4.10 Thermal insulation

4.10.1 Thermal insulation shall be provided as required to protect the hull from temperatures below those allowable (*see* 4.19.1) and to limit the heat flux into the tank to the levels that can be maintained by the pressure and temperature control system applied in Chapter 7.

4.10.2 In determining the insulation performance, due regard should be paid to the amount of the acceptable boil-off in association with the liquefaction or reliquefaction plant on board, gas consumers if present or other temperature control system.

4.13 Functional loads

(Part only shown)

4.13.1 **Internal pressure**

.2 For cargo tanks where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature, P_o shall not be less than the gauge vapour pressure of the cargo at a temperature equal to the maximum daily mean ambient air temperature for the unit's proposed area of operation based on the 100 year average return period. The ambient temperature is to be rounded up to the nearest degree Celsius, and not to be taken as less than 45°C unless agreed by LR.

.4 The internal pressure P_{eq} results from the vapour pressure P_o or P_h plus the maximum associated dynamic liquid pressure P_{gd}, but not including the effects of liquid sloshing loads. Guidance formulae for associated dynamic liquid pressure P_{gd} are given in 4.27.1.

4.14 Environmental loads

4.14.1 **Loads due to ship motion**

The determination of dynamic loads shall take into account the long-term distribution of ship motion in irregular seas, which the ship unit will experience during its operating life. Account may be taken of the reduction in dynamic loads due to heading control.

The motions of the ship unit shall include surge, sway, heave, roll, pitch and yaw. The accelerations, derived from site specific wave data and the heading analysis, acting on tanks, shall be estimated at their centre of gravity and include the following components:

- vertical acceleration: motion accelerations of heave, pitch and possibly roll (normal to the base of the ship unit);
- transverse acceleration: motion accelerations of sway, yaw and roll and gravity component of roll;
- longitudinal acceleration: motion accelerations of surge and pitch and gravity component of pitch.

Methods to predict accelerations due to ship motion shall be proposed and approved by LR.

Guidance formulae for acceleration components are given in 4.27.2.

4.14.3 **Sloshing loads**
The sloshing loads on a cargo containment system and internal components, induced by any of the site-specific motions referred to in 4.14.1, shall be evaluated based on allowable filling levels.
When significant sloshing-induced loads are expected to be present, special tests and calculations shall be required covering the full range of intended filling levels.

4.14.5 **Loads due to operation in ice conditions**
Loads due to operation in ice conditions shall be considered for units intended for such service. The effects on the containment system due to additional topside weight as a result of ice accretion, and ice collisions against the hull should be considered, *see also* Pt 3, Ch 6.

4.15 Accidental loads

4.15.1 **Loads due to flooding**
For independent tanks, loads caused by the buoyancy of an empty tank in a hold space, flooded to the summer load draught, shall be considered in the design of the anti-flotation chocks and the supporting hull structure.

4.17 Structural analyses

4.17.2 **Load scenarios**
For each location or part of the cargo containment system to be considered and for each possible mode of failure to be analysed, all relevant combinations of loads that may act simultaneously shall be considered.
The most onerous load scenarios for all relevant phases of the life-cycle shall be considered. Loads during construction/ handling, installation, on-site operation, inspection/ maintenance including testing and in transit/disconnect conditions shall be considered, as applicable.

4.18 Design conditions

4.18.1 **Ultimate design condition**

4.18.1.2 Analysis shall be based on characteristic load values as follows:

Permanent Loads	Expected Values
Functional Loads	Specified Values
Environmental Loads	For wave loads; most probable largest load encountered by the ship unit during its operating life.

(Part only shown)
4.18.1.3 For the purpose of ultimate strength assessment the following material parameters apply:
.2 The above properties shall correspond to the minimum specified mechanical properties of the material, including the weld metal in the as-fabricated condition. Subject to special consideration by LR, account may be taken of the enhanced yield stress and tensile strength at low temperature.

4.18.1.5 Allowable stresses for materials other than those covered by Chapter 6 shall be subject to approval by LR in each case.

4.18.2 **Fatigue design condition**

4.18.2.2 Where a fatigue analysis is required, the maximum allowable cumulative fatigue damage ratio is to be less than or equal to 0,5, but is to be no greater than 0,33 for any parts of the supporting structure which are not accessible for inspection during the service life of the unit.
The fatigue assessment of the cargo containment system is to be verified in accordance with the ShipRight Procedure for Ship Units.
The loading/unloading history is to be consistent with the intended operation of the ship unit. Plastic strain is to be accounted for in the low cycle region. Loading and unloading cycles are to include a complete pressure and thermal cycle. The fatigue damage shall be based on the design life of the tank but not less than 10^8 wave encounters.

4.18.2.5 Analysis shall be based on characteristic load values as follows:

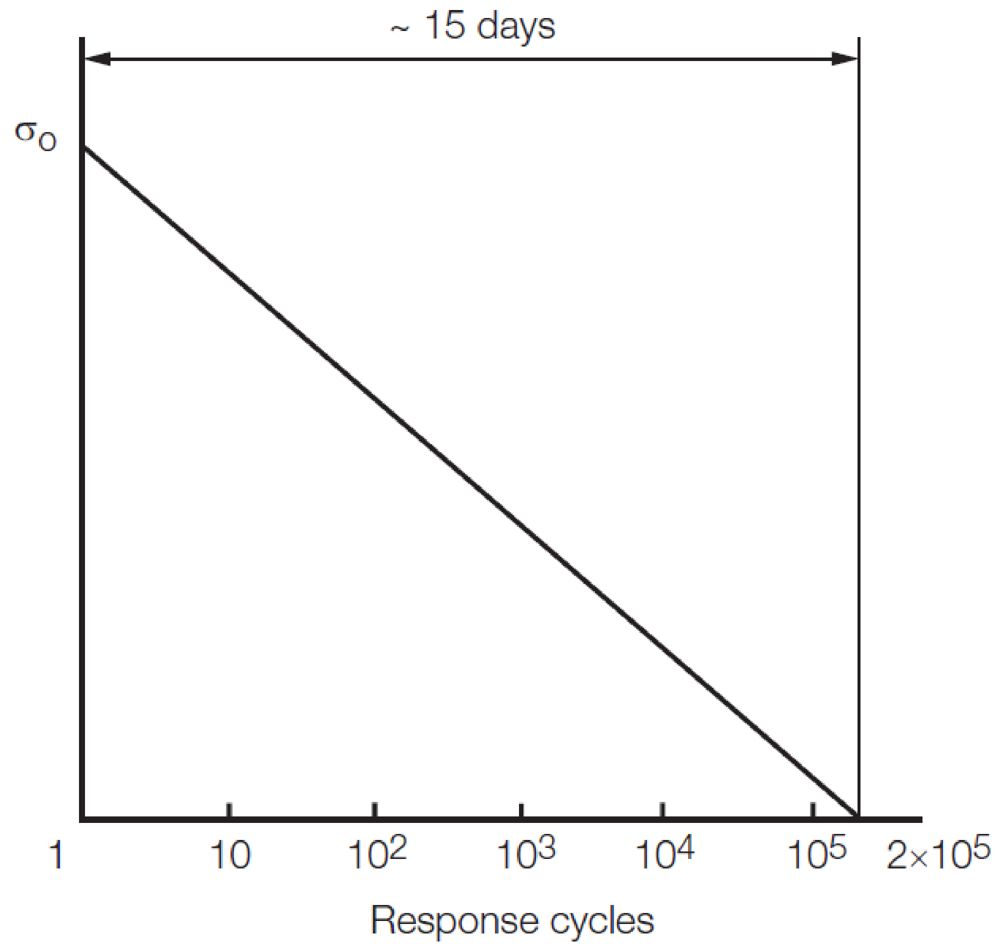
Permanent Loads	Expected Values
Functional Loads	Specified values or specified history
Environmental Loads	Expected load history, but not less than 10^8 cycles

If simplified dynamic loading spectra are used for the estimation of the fatigue life, those shall be specially considered by LR.

4.18.2.6 Where the size of the secondary barrier is reduced, as is provided for in 4.4.3, fracture mechanics analyses of fatigue crack growth shall be carried out for the primary barrier to determine:

- Crack propagation paths in the structure.
- Crack growth rate.
- The time required for a crack to propagate to cause a leakage from the tank.
- The size and shape of through-thickness cracks.
- The time required for detectable cracks to reach a critical state.

The fracture mechanics are in general based on crack growth data taken as a mean value plus two standard deviations of the test data.
In analysing crack propagation the largest initial crack or equivalent defect not detectable by the inspection method applied shall be assumed, taking into account the allowable non-destructive testing and visual inspection criterion as applicable.
For the crack propagation analysis under the condition specified in 4.18.2.7, the simplified load distribution and sequence over a period of 15 days may be used, unless different project-specific requirements apply. Project-specific requirements are to be submitted for consideration. Such distributions may be obtained as indicated in Fig. 4.1. Load distribution and sequence for longer periods, such as in 4.18.2.8 and 4.18.2.9 shall be approved by LR.
The arrangements shall comply with 4.18.2.7 to 4.18.2.9 as applicable:



σ_o = most probable maximum stress over the life cycle of the ship unit

Response cycle scale is logarithmic; the value of 2×10^5 is given as an example of estimate

Fig. 4.1 Simplified load distribution

4.18.2.7 For failures that can be reliably detected by means of leakage detection;

- C_w shall be less than or equal to 0,5.
- The predicted remaining failure development time, from the point of detection of leakage until reaching a critical state, shall not be less than 15 days unless different project-specific requirements apply. Project-specific requirements are to be submitted for consideration.

4.19 Materials

4.19.1 Materials forming the structure of the ship unit

4.19.1.1 To determine the grade of plate and sections used in the hull structure, a temperature calculation shall be performed for all tank types when the cargo temperature is below –10°C. The following assumptions should be made in this calculation:

.1 The primary barrier of all tanks shall be assumed to be at the cargo temperature.

.2 In addition to item 1, where a complete or partial secondary barrier is required it shall be assumed to be at the cargo temperature at atmospheric pressure for any one tank only.

.3 The ambient temperatures for air and sea-water are to be taken at their lowest daily mean temperatures for the unit's proposed area of operation based on the 100 year average return period. The ambient temperatures are to be rounded down to the nearest degree Celsius. The ambient temperatures are not to be taken as greater than 5°C for air and 0°C for sea-water unless agreed by LR.

.4 Still air and sea water conditions shall be assumed, i.e. no adjustment for forced convection.

.5 Degradation of the thermal insulation properties over the life of the ship unit due to factors such as thermal and mechanical ageing, compaction, ship motions and tank vibrations as defined in 4.19.3.6 and 4.19.3.7 shall be assumed.

.6 The cooling effect of the rising boil-off vapour from the leaked cargo should be taken into account where applicable.

.7 No credit shall be given for any means of heating, except as described in 4.19.1.5.

.8 For members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.

4.19.1.2 The shell and deck plating of the ship unit and all stiffeners attached thereto shall be in accordance with the requirements of Part 10 and this Part. If the calculated temperature of the material in the design condition is below –5°C due to the influence of the cargo temperature and ambient sea and air temperatures, the material shall be in accordance with Table 6.5. The ambient sea and air temperatures are to be determined as defined in 4.19.1.1.3.

4.19.1.3 The materials of all other hull structures for which the calculated temperature in the design condition is below 0°C, due to the influence of cargo temperature and ambient sea and air temperatures, and that do not form the secondary barrier, shall also be in accordance with Table 6.5. This includes hull structure supporting the cargo tanks, inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members. The ambient sea and air temperatures are to be determined as defined in 4.19.1.1.3.

4.19.1.5 Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in Table 6.5. In the calculations required in 4.19.1.1, credit for such heating may be taken in accordance with the following:

.1 for any transverse hull structure;

.2 for longitudinal hull structure referred to in 4.19.1.2 and 4.19.1.3 where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of +5°C for air and 0°C for sea-water with no credit taken in the calculations for heating; and

.3. as an alternative to 4.19.1.5.2, for longitudinal bulkhead between cargo tanks, credit may be taken for heating provided the material remains suitable for a minimum design temperature of –30°C, or a temperature 30°C lower than that determined by 4.19.1.1 with the heating considered, whichever is less. In this case, the longitudinal strength of the ship unit shall comply with SOLAS Regulation II-1/3-1 for both when those bulkhead(s) are considered effective and not.

4.19.1.6 The means of heating referred to in 4.19.1.5 shall comply with the following requirements:

.1 the heating system shall be arranged so that, in the event of failure in any part of the system, standby heating can be maintained equal to not less than 100 per cent of the theoretical heat requirement;

.2 the heating system shall be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with 4.19.1.5.1 shall be supplied from the emergency source of electrical power; and

.3 the design and construction of the heating system shall be included in the approval of the containment system by LR.

4.19.2 **Materials of primary and secondary barriers**

4.19.2.2 Materials, either non-metallic or metallic but not covered by Tables 6.1, 6.2 and 6.3, used in the primary and secondary barriers may be approved by LR considering the design loads that they may be subjected to, their properties and their intended use.

4.19.2.3 Where non-metallic materials, including composites, are used for or incorporated in the primary or secondary barriers, they shall be tested for the following properties, as applicable, to ensure that they are adequate for the intended service:

- compatibility with the cargoes;
- solubility in cargo;
- absorption of cargo;
- ageing;
- density;
- mechanical properties;
- thermal expansion and contraction;
- abrasion;
- cohesion;
- resistance to vibrations;
- resistance to fire and flame spread;
- resistance to fatigue failure and crack propagation;
- influence of water;
- resistance to cargo pressure.

4.19.2.5.1 Guidance on the use of non-metallic materials in the construction of primary and secondary barriers is provided in Appendix 1.

4.19.3 **Thermal insulation and other materials used in cargo containment systems**

4.19.3.4 Due to location or environmental conditions, thermal insulation materials shall have suitable properties of resistance to fire and flame spread and shall be adequately protected against penetration of water vapour and mechanical damage. Where the thermal insulation is located on or above the exposed deck, and in way of tank cover penetrations, it shall have suitable fire resistance properties in accordance with a recognised Standard acceptable to LR or be covered with a material having low flame spread characteristics and forming an efficient approved vapour seal.

4.19.3.5 Thermal insulation that does not meet recognised Standards acceptable to LR for fire resistance may be used in hold spaces that are not kept permanently inerted, provided its surfaces are covered with material with low flame spread characteristics and that forms an efficient approved vapour seal.

4.19.3.7 Where powder or granulated thermal insulation is used, measures shall be taken to reduce compaction in service, for example due to vibrations, and to maintain the required thermal conductivity and also prevent any undue increase of pressure on the cargo containment system.

4.20 Construction processes

4.20.1 **Weld joint design**

4.20.1.2 Welding joint details for Type C independent tanks, and for the liquid-tight primary barriers of Type B independent tanks primarily constructed of curved surfaces, shall be as follows:

.1 All longitudinal and circumferential joints shall be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds shall be obtained by double welding or by the use of backing rings. If used, backing rings shall be removed except from very small process pressure vessels. Other edge preparations may be permitted, depending on the results of the tests carried out at the approval of the welding procedure.

.2 The bevel preparation of the joints between the tank body and domes and between domes and relevant fittings shall be designed according to a standard acceptable to LR. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles shall be full penetration welds.

4.20.3 **Testing during construction**

4.20.3.3 Requirements with respect to inspection of secondary barriers shall be decided by LR in each case, taking into account the accessibility of the barrier. *See also* 4.6.2.

4.20.3.4 The Administration may require that, for ship units fitted with novel Type B independent tanks, at least one prototype tank and its supporting structures shall be instrumented with strain gauges or other suitable equipment to confirm stress levels. Similar instrumentation may be required for Type C independent tanks, depending on their configuration and on the arrangement of their supports and attachments.

4.20.3.5 The overall performance of the cargo containment system shall be verified for compliance with the design parameters during entry into service in accordance with the survey procedure. Records of the performance of the components and equipment, essential to verify the design parameters, shall be maintained and be available to the Administration.

4.20.3.7 The cargo containment system shall be inspected for cold spots during or immediately following entry into service. Inspection of the integrity of thermal insulation surfaces that can not be visually checked shall be carried out in accordance with recognised Standards.

4.21 Type A independent tanks

4.21.1 **Design basis**

4.21.1.1 Type A independent tanks are tanks primarily designed using classical ship-structural analysis procedures. Type A independent tanks are to be designed in accordance with LR 4.21.1 and LR 4.21.2. Where such tanks are primarily constructed of plane surfaces, the design vapour pressure P_o shall be less than 0,07 MPa.

4.21.2 **Structural analysis**

4.21.2.1 A structural analysis shall be performed taking into account the internal pressure as indicated in 4.13.1, and the interaction loads with the supporting and keying system as well as a reasonable part of the hull of the ship unit.

4.21.2.2 For parts such as supporting structures not otherwise covered by the requirements of this Part, stresses shall be determined by direct calculations, taking into account the loads referred to in 4.12 to 4.15 as far as applicable, and the deflection of the ship unit in way of supporting structures.

4.21.2.3 The tanks with supports shall be designed for the accidental loads specified in 4.15. These loads need not be combined with each other or with environmental loads.

(Part only shown)

LR 4.21.2 The scantlings of Type A independent tanks are to comply with the following:

(b) **Boundary plating.**

NOTE

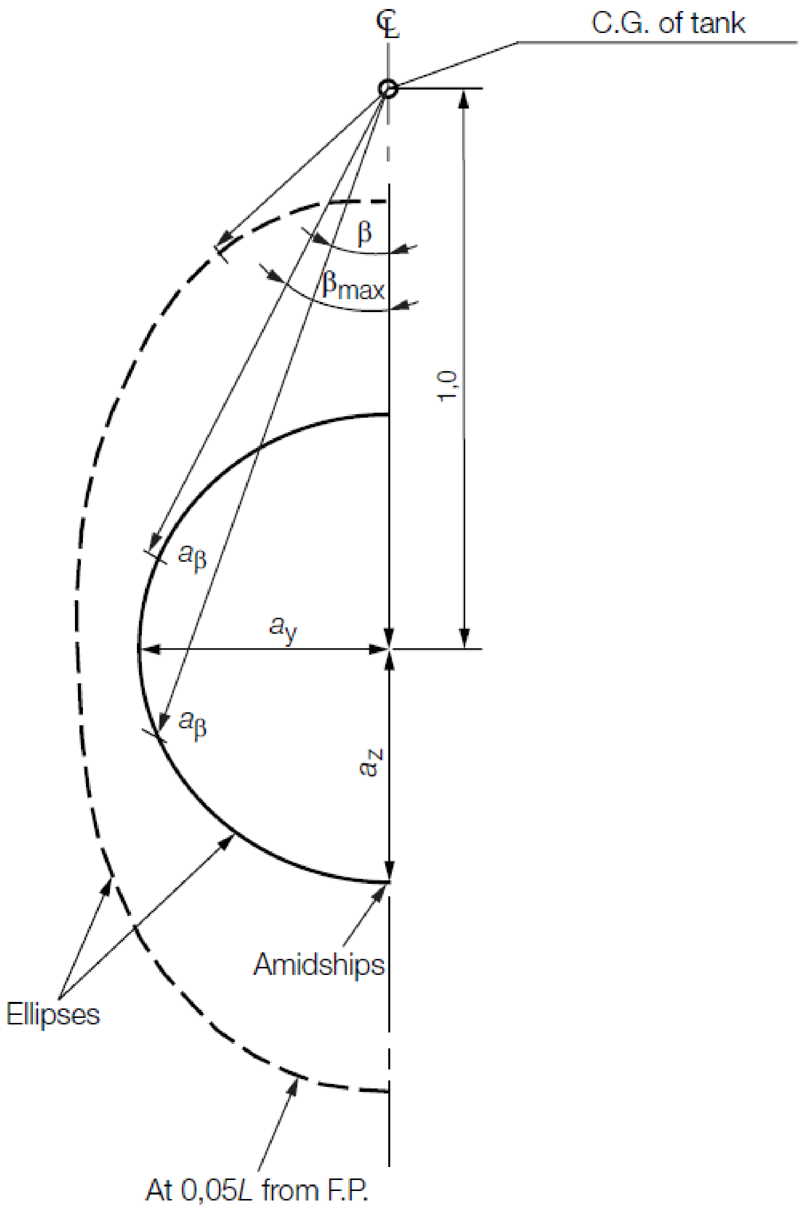
An additional corrosion allowance of 1 mm is to be added to the thickness derived if the cargo is of corrosive nature, *see also* 4.3.5 and LR 4.3.3.

4.21.3 **Ultimate design condition**

4.21.3.1 For tanks primarily constructed of plane surfaces, the nominal membrane stresses for primary and secondary members (stiffeners, web frames, stringers, girders), when calculated by classical analysis procedures, shall not exceed the lower of $R_m/2,66$ or $R_e/1,33$ for nickel steels, carbon-manganese steels, austenitic steels and aluminium alloys, where R_m and R_e are defined in 4.18.1.3.

However, if detailed calculations are carried out for the primary members, the equivalent stress σ_c, as defined in 4.18.1.4, may be increased over that indicated above to a stress acceptable to LR. Calculations shall take into account the effects of bending, shear, axial and torsional deformation as well as the hull/cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottoms.

4.21.3.2 Tank boundary scantlings shall meet at least the requirements of LR for deep tanks taking into account the internal pressure as indicated in 4.13.1 and any corrosion allowance required by 4.3.5 or LR 4.3.3.



a_β = resulting acceleration (static and dynamic) in arbitrary direction β
a_y = transverse component of acceleration
a_z = vertical component of acceleration

Fig. 4.2 Acceleration ellipse

4.22 Type B independent tanks

4.22.2 **Structural analysis**

4.22.2.2 A three-dimensional analysis shall be carried out to evaluate the stress levels, including interaction with the hull of the ship unit. The model for this analysis shall include the cargo tank with its supporting and keying system, as well as a reasonable part of the hull.

4.22.2.3 A complete analysis of the particular accelerations and motions of the ship unit in irregular waves, and of the response of the ship unit and its cargo tanks to these forces and motions shall be performed unless the data is available from similar ship units.

(Part only shown)
LR 4.22.1

(b) Generally, the scantlings of cargo tanks primarily constructed of plane surfaces are not to be less than required by LR 4.21.2 for Type A independent tanks. In assessing the cumulative effect of the fatigue load, account is to be taken of the quality control aspects such as misalignment, distortion, fit-up and weld shape. A 97,7 per cent survival probability S–N curve is to be adopted in association with a cumulative damage factor C_w value of 0,1 for primary members and 0,5 for secondary members. Alternative proposals will be specially considered.

4.22.3 **Ultimate design condition**

(Part only shown)
4.22.3.1 **Plastic deformation**
For Type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses shall not exceed:
with R_m and R_e as defined in 4.18.1.3. With regard to the stresses σ_m, σ_L and σ_b *see also* the definition of stress categories in 4.27.3. The values *A, B, C and D* shall have at least the minimum values shown in Table 4.22.1. For Type B independent tanks, primarily constructed of plane surfaces, the allowable stress levels will be specially considered: The thickness of the skin plate and the size of the stiffener shall not be less than those required for Type A independent tanks.

4.23 Type C independent tanks

4.23.1 **Design basis**

(Part only shown)
4.23.1.2 The design vapour pressure shall not be less than:
with

h = height of tank (dimension in ship unit's vertical direction) (m)

b = width of tank (dimension in ship unit's transverse direction) (m)

l = length of tank (dimension in ship unit's longitudinal direction) (m)

4.23.2 **Shell thickness**

(Part only shown)
4.23.2.1 The shell thickness shall be as follows:
.3 The welded joint efficiency factor to be used in the calculation according to 4.23.2.4 shall be 0,95 when the inspection and the non-destructive testing referred to in Chapter 6 are carried out. This value may be increased up to 1,0 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels LR may accept partial non-destructive examinations, but not less than those of Chapter 6, depending on such factors as the material used, the design temperature, the nil-ductility transition temperature of the material as fabricated and the type of joint and welding procedure, but in this case an efficiency factor of not more than 0,85 should be adopted. For special materials the above-mentioned factors shall be reduced, depending on the specified mechanical properties of the welded joint.

LR 4.23.3 The thickness of pressure parts subject to internal pressure is to be in accordance with Pt 5, Ch 11 of the Rules for Ships except that:

(a) the welded joint efficiency factor, J, is to be as defined in 4.23.2.1.3;

(b) the allowable stress is to be in accordance with 4.23.3.1;

(c) the constant thickness increment (0,75 mm) included in the formulae in Pt 5, Ch 11,2 of the Rules for Ships may require to be increased in accordance with 4.3.5 or LR 4.3.3.

4.23.2.5 Stress analysis in respect of static and dynamic loads shall be performed as follows:

.1 Pressure vessel scantlings shall be determined in accordance with 4.23.2.4.

.2 Calculations of the loads and stresses in way of the supports and the shell attachment of the support shall be made. Loads referred to in 4.12 to 4.15 shall be used, as applicable. Stresses in way of the supporting structures shall be to a recognised standard acceptable to LR. In special cases a fatigue analysis may be required by LR.

.3 If required by LR, secondary stresses and thermal stresses shall be specially considered.

4.23.4 **Fatigue design condition**
For large Type C independent tanks where the cargo at atmospheric pressure is below –55°C, LR may require additional verification to check their compliance with 4.23.1.1, regarding static and dynamic stress.

4.24 Membrane tanks

4.24.4 Structural analyses

4.24.4.3 The analyses referred to in 4.24.4.1 and 4.24.4.2 shall be based on the particular motions, accelerations and response of ship units and cargo containment systems.

4.24.9 Testing

In ship units fitted with membrane cargo containment systems, all tanks and other spaces that may normally contain liquid and are adjacent to the hull structure supporting the membrane, shall be hydrostatically tested.
All hold structures supporting the membrane shall be tested for tightness before installation of the cargo containment system.
Pipe tunnels and other compartments that do not normally contain liquid need not be hydrostatically tested.

4.25 Integral tanks

4.25.1 Design basis

Integral tanks that form a structural part of the hull and are affected by the loads that stress the adjacent hull structure shall comply with the following:

.1 The design vapour pressure P_o as defined in 4.1.2 shall not normally exceed 0,025 MPa. If the hull scantlings are increased accordingly, P_o may be increased to a higher value, but less than 0,07 MPa.

.2 Integral tanks may be used for products provided the boiling point of the cargo is not below –10°C. A lower temperature may be accepted by LR subject to special consideration, but in such cases a complete secondary barrier shall be provided.

4.27 Guidance Notes for Chapter 4

4.27.1. Guidance to detailed calculation of internal pressure for static design purpose

4.27.1.1 This Section provides guidance for the calculation of the associated dynamic liquid pressure for the purpose of static design calculations. This pressure may be used for determining the internal pressure given in 4.13.1.4.
P_{gd} is the associated maximum liquid pressure determined using site-specific accelerations.
P_{eq} is to be calculated as follows:

$P_{eq} = P_o + P_{gd}$ (MPa)

(Part only shown)
4.27.1.2 The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the cargo due to the motions of the ship unit referred to in 4.14.1. The value of internal liquid pressure P_{gd} resulting from combined effects of gravity and dynamic accelerations shall be calculated as follows:

α_β = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β, (*see* Fig. 4.2)
Note for large tanks an acceleration ellipsoid, taking account of transverse vertical and longitudinal accelerations should be used

Z = largest liquid height (in metres) above the point where the pressure is to be determined measured from the tank shell in the β direction (*see* Fig. 4.3) Tank domes considered to be part of the accepted total tank volume shall be taken into account when determining Z_β unless the total volume of tank domes V_d does not exceed the following value:

The direction that gives the maximum value of P_{gd} shall be considered. Where acceleration components in three directions need to be considered, the ellipsoid shown in Fig. 4.4 shall be used instead of the ellipse in Fig. 4.2. The above formula applies only to full tanks.

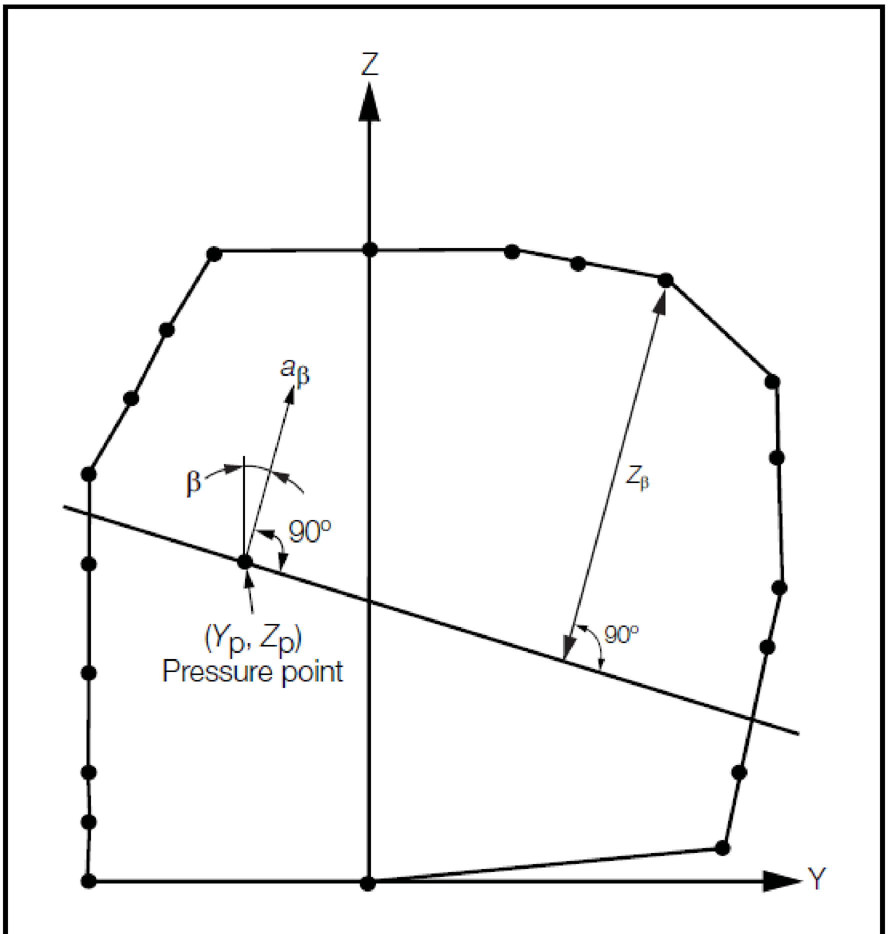


Fig. 4.3 Determination of internal pressure heads

LR 4.27.2 Accelerations in three dimensions are to be considered for ship units with independent spherical Type B tanks for which the ellipsoid as shown in Fig. 4.4 is to be used. Where loading conditions are proposed including one or more partially filled tanks, the internal liquid pressure to be used will be specially considered. *See also* 4.14.3.

4.27.1.3 Equivalent calculation procedures may be applied.

4.27.2 **Guidance formulae for acceleration components**

(Part only shown)
LR 4.27.3 The following formulae are given as guidance for the determination of the maximum value of internal liquid pressure head P_{gd}, (*see* 4.27.1, internal pressure).
In the transverse direction, as shown in Fig. 4.2, the following apply:

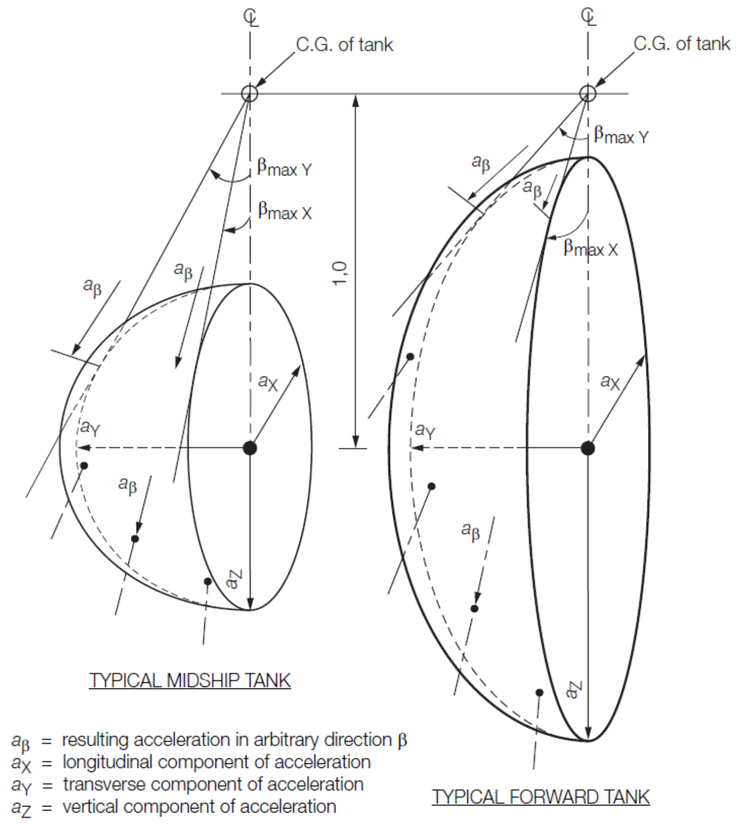


Fig. 4.4 Acceleration ellipsoids

4.27.3 **Stress categories**

4.27.3.1 For the purpose of stress evaluation, stress categories are defined in this Section.

4.27.3.2 **Normal stress** is the component of stress normal to the plane of reference.

4.27.3.3 **Membrane stress** is the component of normal stress that is uniformly distributed and equal to the average value of the stress across the thickness of the section under consideration.

4.27.3.4 **Bending stress** is the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.

4.27.3.5 **Shear stress** is the component of the stress acting in the plane of reference.

4.27.3.6 **Primary stress** is a stress produced by the imposed loading, which is necessary to balance the external forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses that considerably exceed the yield strength will result in failure or at least in gross deformations.

4.27.3.7 **Primary general membrane stress** is a primary membrane stress that is so distributed in the structure that no redistribution of load occurs as a result of yielding.

(Part only shown)
4.27.3.8 **Primary local membrane stress** arises where a membrane stress produced by pressure or other mechanical loading and associated with a primary or a discontinuity effect produces excessive distortion in the transfer of loads for other portions of the structure. Such a stress is classified as a primary local membrane stress, although it has some characteristics of a secondary stress. A stress region may be considered as local if:

4.27.3.9 **Secondary stress** is a normal stress or shear stress developed by constraints of adjacent parts or by self-constraint of a structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions that cause the stress to occur.

Process Pressure Vessels and Liquids, Vapour and Pressure Piping Systems and Offshore Arrangements

5.2 System requirements

5.2.1 **Arrangements – General**

5.2.1.2 Suitable means shall be provided to relieve the pressure and remove liquid cargo from discharging headers; likewise, any piping between the outermost discharge valves and loading arms or cargo hoses or any other location prior to the outermost valve that may be subject to pressurisation during discharging operations.

5.2.1.4 Relief valves discharging liquid cargo from the piping system shall discharge into the cargo tanks. Alternatively, they may discharge to the flare system which is to be designed in accordance with API 521 *Guide for Pressure-relieving and Depressuring Systems: Petroleum petrochemical and natural gas industries-Pressure relieving and depressuring systems*. Where required to prevent overpressure in downstream piping, relief valves on cargo pumps shall discharge to the pump suction.

5.5 System requirements

Every cargo tank and piping system shall be fitted with manually-operated valves for isolation purposes as specified in this Section. In addition, remotely operated valves shall also be fitted, as appropriate, as part of the emergency shut-down (ESD) system. The purpose of this ESD system is to stop cargo flow or leakage in the event of an emergency when cargo liquid or vapour transfer is in progress.
The ESD system is intended to return the cargo system to a safe static condition so that any remedial action can be taken. Due regard shall be given in the design of the ESD system to avoid the generation of surge pressures within the cargo transfer pipework.
The equipment to be shut down on ESD activation includes; manifold valves during loading or discharge, any pump or compressor etc transferring cargo internally or externally (e.g. to a shuttle tanker) plus cargo tank valves if the MARVS exceeds 0,07 MPa.

5.5.2 **Cargo offloading connections**
The offloading station is to provide a remotely controlled ESD valve prior to the hose connection to prevent liquid and vapour to or from the facility in the event of an incident. In the event that one or more transfer hoses are not used a manual and controlled by permit (or similar method) stop valve is to be provided prior to the hose connection.
In the event that the vapour return line is closed the ESD system is to be designed to stop all cargo pumping.
If the cargo tank MARVS exceeds 0,07 MPa an additional manual valve shall be provided for each transfer connection in use, and may be inboard or outboard of the ESD valve to suit the design of the ship unit.

5.5.3 Cargo tank connections for gauging or measuring devices need not be equipped with excess flow valves or ESD valves provided that the devices are constructed so that the outward flow of tank contents cannot exceed that passed by a 1,5 mm diameter circular hole.

5.5.4 All pipelines or components which may be isolated in a liquid full condition shall be protected with relief valves for thermal expansion and evaporation.

5.5.5 All pipelines or components which may be isolated automatically due to a fire with a liquid volume of more than 0,05 m^3 entrapped shall be provided with PRVs sized for a fire condition.

5.6 Cargo transfer arrangements

5.6.3 **Vapour return connections**
Connections for vapour return from the shuttle tanker to the ship unit shall be provided.

5.6.6 **Cargo filters**
It is anticipated that liquefied gas facilities will remove contaminants before liquefaction. In the event that further filtration is anticipated, e.g., cool down during commissioning, the following shall be applied.
The cargo liquid and vapour systems shall be capable of being fitted with filters to protect against damage by foreign objects. Such filters may be permanent or temporary, and the standards of filtration shall be appropriate to the risk of debris, etc., entering the cargo system. Means shall be provided to indicate that filters are becoming blocked. Means shall be provided to isolate, depressurise and clean the filters safely.

5.7 Installation requirements

5.7.2 Precautions against low temperature

Low temperature piping shall be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at cargo transfer connections and at pump seals, protection for the hull beneath shall be provided.

5.7.3 Cryogenic protection

Cryogenic protection against spills is to be provided for temperatures below –110°C, such systems are to provide adequate coverage of hull, main decks, process decks, process support structures and other vulnerable equipment within the process area. These systems are to consider spillage, cryogenic jets and cryogenic pooling, and their size and scope are to be based on the process area inventories of the cryogenic material. The design of such systems is to ensure that they are constantly available and not reactive to an event.

Areas of the facility used for the discharge of cryogenic material may employ a water curtain for protection during such operations and is additional to the requirements of 11.3.1.4.

5.7.4. Bonding

Where tanks or cargo piping and piping equipment are separated from the structure of the ship unit by thermal isolation, provision shall be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded. Except where bonding straps are used, it shall be demonstrated that the electrical resistance of each joint or connection is less than 1 MΩ.

5.9 Welding, post-weld heat treatment and non-destructive testing

5.9.2 Post-weld heat treatment

Post-weld heat treatment shall be required for all butt welds of pipes made with carbon, carbon manganese and low alloy steels. LR may waive the requirements for thermal stress relieving of pipes with wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.

(Part only shown)

5.9.3. Non-destructive testing

In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the requirements of this paragraph, the following tests shall be required:

.2. When such butt-welded joints of piping sections are made by automatic welding procedures approved by LR, then a progressive reduction in the extent of radiographic or ultrasonic inspection can be agreed, but in no case to less than 10 per cent of each joint. If defects are revealed the extent of examination shall be increased to 100 per cent and shall include inspection of previously accepted welds. This approval can only be granted if well-documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently; and

.3. For other butt-welded joints of pipes not covered by 5.9.3.1 and 5.9.3.2, spot radiographic or ultrasonic inspection or other non-destructive tests shall be carried out depending upon service, position and materials. In general, at least 10 per cent of butt-welded joints of pipes shall be subjected to radiographic or ultrasonic inspection.

5.10 Installation requirements for cargo piping outside the cargo area

5.10.1 Bow and stern loading arrangements

The following provisions apply to cargo piping and related piping equipment located outside the cargo area:

.1 Cargo piping and related piping equipment outside the cargo area shall have only welded connections. The piping outside the cargo area shall run on the weather decks and shall be at least 0,8 m inboard, except for cargo transfer connection piping. Such piping shall be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location it shall also be capable of being separated, by means of a removable spool piece and blank flanges, when not in use.

.2 The piping is to be full penetration butt-welded and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping shall only be permitted within the cargo area and at the cargo transfer connections.

5.11 Piping system component requirements

5.11.3 Allowable stress

5.11.3.3 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness shall be increased over that required by 5.11.2 or, if this is impracticable or would cause excessive local stresses, these loads shall be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to; supporting structures, deflections of the ship unit, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.

5.11.5 **Stress analysis**
When the design temperature is –110°C or colder, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hogging and sagging of the ship unit for each branch of the piping system shall be submitted to LR. For temperatures above –110°C, a stress analysis may be required by LR in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration should be given to thermal stresses even though calculations are not submitted. The analysis may be carried out according to a Code of Practice acceptable to LR.

5.11.6 **Flanges, valves and fittings**

5.11.6.2 For flanges not complying with a recognised Standard, the dimensions of flanges and related bolts shall be to the satisfaction of LR.

5.11.7. **Ship unit cargo hoses**

5.13 Testing requirements

5.13.1 **Type testing of piping components**

5.13.1.1 **Valves**
Reference is made to the SIGTTO publication *The Selection and Testing of Valves for LNG Applications*.
Each type of piping component shall be subject to the following type tests:
Each type of piping component intended to be used at a working temperature below –55°C shall be subject to the following type tests:

.1 Each size and type of valve shall be subjected to seat tightness testing over the full range of operating pressures for bi-directional flow and temperatures, at intervals, up to the rated design pressure of the valve. Allowable leakage rates shall be to the requirements of LR. During the testing satisfactory operation of the valve shall be verified.

.2 The flow or capacity shall be certified to a recognised Standard for each size and type of valve.

.3 Pressurised components shall be pressure tested to at least 1,5 times the rated pressure.

.4 For emergency shutdown valves, with materials having melting temperatures lower than 925°C, the type testing shall include a fire test to a standard acceptable to the Administration. Reference is made to API Std 607 *Fire Test for Soft Seated Quarter Turn Valves.*

(Part only shown)
5.13.1.2 **Expansion bellows**
The following type tests shall be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and where required by the Recognised Organisation, on those installed within the cargo tanks:

.4 A cyclic fatigue test (deformation of the ship unit) shall be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2 000 000 cycles at a frequency not higher than 5 Hz. This test is only required when, due to the piping arrangement, deformation loads from the ship unit are actually experienced.

5.13.2 **System testing requirements**

5.13.2.2 After assembly, all cargo and process piping shall be subjected to a strength test with a suitable fluid. The test pressure is to at least 1,5 times the design pressure (1,25 times the design pressure where the test fluid is compressible) for liquid lines and 1,5 times the maximum system working pressure (1,25 times the maximum system working pressure where the test fluid is compressible) for vapour lines. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the test may be conducted prior to installation onboard the ship unit. Joints welded onboard shall be tested to at least 1,5 times the design pressure.

LR 5.14 Cryogenic liquefied gas spill control

Section LR 5.14 is underlined in its entirety.

LR 5.15 Liquefied gas transfer systems – General requirements

Section LR 5.15 is underlined in its entirety.

Part 11, Chapter 11

Fire Prevention and Extinction

11.1 Fire safety requirements

11.1.1 In general, the requirements for tankers in SOLAS Chapter ll-2 are to apply to ship units covered by this Part, irrespective of tonnage of the unit, with the exception of the following:

.1 regulations 4.5.1.6 and 4.5.10 do not apply;

.2 regulation 10.2 as applicable to cargo ships, and regulations 10.4 and 10.5 are in general to apply to the hull structure of the installation, as they would apply to tankers of 2000 gross tonnage and over;

.3 regulation 10.5.6 is to apply to the hull structure;

.4 the following regulations of SOLAS Chapter II-2 related to tankers do not apply and are replaced by the Chapters and Sections of this Part as detailed below:

Regulation	**Replaced by**
10.10	Part 11, 11.6
4.5.1.1 and 4.5.1.2	Part 11, Chapter 3
4.5.5 and 10.8	Part 11, 11.3 and 11.4
10.9	Part 11, 11.5
10.2	Part 11, 11.2.1 to 11.2.4

.5 regulations 13.3.4 and 13.4.3 shall apply to the ship unit.

11.2 Fire mains and hydrants

11.2.1 All ship units, irrespective of size, with bulk liquefied gas storage and/or vapour discharge and loading manifolds/facilities, carrying products specified in Chapter 19 are in general to comply with the requirements of SOLAS regulations ll-2/10.2, except that the required fire pump capacity and fire main and water service pipe diameter should not be limited by the provisions of regulations ll-2/10.2.2.4.1 and ll-2/10.2.1.3. When a fire pump is used as part of the water spray system, as permitted by 11.3.3 of this Chapter, the capacity of this fire pump shall be such that these areas can be protected when simultaneously supplying two jets of water from fire hoses with 19 mm nozzles at a pressure of at least 5,0 bar gauge for hydrants located at hull, hull weather deck and liquefied gas offloading facilities. For hydrant located on topsides facilities, the pressure should be at least 3,5 bar gauge for two operational hydrants.

11.2.2 The arrangements shall be such that at least two jets of water can reach any part of the deck in the cargo area, those portions of the cargo containment system and tank covers that are above the deck, and topside areas. The necessary number of fire hydrants shall be located to satisfy the above arrangements and to comply with the requirements of SOLAS regulations ll-2/10.2.1.5.1 and ll-2/10.2.3.3, taking into account the length of the hoses used at the location. The hose length should be 15 m in hull machinery spaces and should not be greater than 20 m in topsides areas, due to space constraints to enable the hose to be laid out by a fire team in a fire incident.

11.2.3 Stop valves shall be fitted in any crossover provided and in the fire main or mains in a protected location, before entering the cargo area and at intervals ensuring isolation of any damaged single section of the fire main, so that regulation 11.2.2 can be complied with using not more than two lengths of hoses from the nearest fire hydrant. The water supply to the fire main serving the cargo area shall be a ring main supplied by the main fire pumps or a single main supplied by fire pumps positioned outside the cargo area. The main installation firewater pumps are to be positioned to ensure a high degree of firewater pump redundancy and firewater supply integrity in potential major installation fire scenarios.

11.3 Water-spray system

(Part only shown)
11.3.1 A water application system, which may be based on water-spray nozzles, for cooling, fire prevention and crew protection shall be installed to cover:

.7 any semi-enclosed cargo machinery spaces and semi-enclosed cargo motor room.

11.3.3 The capacity of the water application pumps shall be capable of simultaneous protection of any two complete athwartship tank groupings, including any gas process units within these areas in addition to surfaces specified in 11.3.1.4, 5, 6, 7 and 8. Alternatively, the main fire pumps may be used for this service provided that their total capacity is increased by the amount needed for the water-spray application system. In either case a connection, through a stop valve, shall be made between the fire main and waterspray application system main supply line outside of the cargo area. *See also* LR 11.2.1.

11.3.4 <u>The maximum credible firewater demand should be determined in the installation Fire and Explosion Evaluation (FEE) based on the credible activation of water spray systems detailed in 11.3 and any additional topside module and hydrant demands.</u>

11.3.6 All pipes, valves, nozzles and other fittings in the water application systems shall be resistant to corrosion by seawater. <u>Galvanised pipework may be considered for this service but copper nickel alloy or stainless steel pipework which is rated for marine/sea-water/fire-fighting service is recommended for installations.</u> Piping, fittings and related components within the cargo area (except gaskets) shall be designed to withstand 925°C. The water application system shall be arranged with in-line filters to prevent blockage of pipes and nozzles. In addition means shall be provided to back flush the system with fresh water.

11.4 Dry chemical powder fire-extinguishing systems

11.4.1 <u>Dependent upon the conclusions of the Fire and Explosion Evaluation (FEE) and the installation's fire-fighting and safety philosophy, consideration for ship units should be given to the provision of</u> fixed dry chemical powder fire-extinguishing systems, complying with the provisions of the FSS Code, for the purpose of fire-fighting on the deck in the cargo area, including <u>all</u> cargo liquid and vapour discharge and loading connections on deck and cargo handling areas as applicable.

11.4.2 The system shall be capable of delivering powder from at least two hand hose lines, or a combination of monitor/hand hose lines, to any part of the exposed <u>cargo area</u>, cargo liquid and vapour piping, load/unload connections and exposed gas process units.

11.4.6 Hand hose lines shall be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration shall be given where areas to be protected are substantially higher than the monitor or hand hose reel locations. <u>*See also* LR 11.4.1 regarding topsides process areas.</u>

11.4.7 <u>Ship units</u> fitted with bow, stern load/unload connections shall be provided with independent dry powder units protecting the cargo liquid and vapour piping, aft or forward of the cargo area, by hose lines and a monitor covering the bow, stern load/unload complying with the requirements of 11.4.1 to 11.4.6.

11.4.<u>8</u> After installation, the pipes, valves, fittings and assembled systems shall be subjected to a tightness test and functional testing of the remote and local release stations. The initial testing shall also include a discharge of sufficient amounts of dry chemical powder to verify that the system is in proper working order. All distribution piping shall be blown through with dry air to ensure that the piping is free of obstructions.

11.5 Enclosed spaces containing cargo handling equipment

11.5.1 Enclosed spaces meeting the criteria of cargo machinery spaces in Ch 1, 1.2.9, and the cargo motor room within the cargo area of any ship <u>unit</u>, shall be provided with a fixed fire extinguishing system complying with the provisions of the FSS Code and taking into account the necessary concentrations/application rate required for extinguishing gas fires.

11.5.<u>2</u> <u>The fire risks associated with the</u> turret compartments of any ship unit <u>are to be fully assessed within the installation Fire and Explosion Evaluation (FEE). The firefighting/ mitigating measures associated with the turret (i.e., water spray, passive fire protection, isolation and blowdown, etc.) are to be based upon the fire risks determined within the Fire and Explosion Evaluation (FEE) and should be in line with the overall installation's fire-fighting and safety philosophy.</u>

11.6 Firefighter's outfits

(Part only shown)
11.6.1 Every ship <u>unit</u> shall carry firefighter's outfits complying with the requirements of SOLAS regulation II-2/10.10 as follows:

Part 11, Chapter 13

Instrumentation and Automation Systems

13.1 General

13.1.3. If loading and unloading of the ship <u>unit</u> is performed by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank shall be concentrated in one control position.

13.1.4 Instruments shall be tested to ensure reliability under the working conditions. Test procedures for instruments and the intervals between testing and recalibration shall be in accordance with manufacturer's recommendations, <u>or at a period developed by risk assessment.</u>

13.3 Overflow control

13.3.1 Each cargo tank shall be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.

13.3.4 The position of the sensors in the tank shall be capable of being verified before commissioning. At first loading, and after each dry-docking, testing of high level alarms shall be conducted by raising the cargo liquid level in the cargo tank to the alarm point.

13.3.5 All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, shall be capable of being functionally tested. Systems shall be tested prior to cargo operation in accordance with 18.6.2.

13.4 Pressure monitoring

13.4.3 For cargo tanks fitted with PRVs, which can be set at more than one set pressure in accordance with 8.2.7, high-pressure alarms shall be provided for each set pressure. A permit to work system advising which PRV setting is in use is to be provided.

13.4.5 Local-reading manifold pressure indication shall be provided to indicate the pressure between manifold valves of the ship unit and hose connections to the shuttle tanker.

13.5 Temperature indicating devices

13.5.1 Each cargo tank shall be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the cargo tank and the second near the top of the tank, below the highest allowable liquid level. The lowest temperature for which the cargo tank has been designed, consistent with the assigned class notation, shall be clearly indicated by means of a sign on or near the temperature indicating devices.

13.6 Gas detection

13.6.1 Gas detection equipment shall be installed to monitor the integrity of the cargo containment, cargo handling and ancilliary systems in accordance with this Section. However, the overall provision of gas detection on the installation should be defined based on ignition risk mitigating measures and philosophy derived for the installation via the Fire and Explosion Evaluation (FEE).

(Part only shown)
13.6.2 A permanently installed system of gas detection and audible and visual alarms shall be fitted in:

.1 all enclosed cargo and cargo machinery spaces (including turrets compartments) or similar enclosures containing gas piping, gas equipment or gas consumers;

However, the overall provision of gas detection on the installation should be defined based on ignition risk mitigating measures and philosophy derived for the installation via the Fire and Explosion Evaluation (FEE).
The various fire and gas detectors should feed signals into a robust fire and gas detection system/panel, in accordance with the requirements of Pt 7, Ch 1,2. High level fire and gas signals, along with process hazard signals are then to feed into a robust Emergency Shut-down (ESD) System, in accordance with the requirements of Chapter 18 and Pt 7, Ch 1,7.

13.6.3 Gas detection equipment shall be designed, installed and tested in accordance with IEC 60079-29-1 – *Explosive atmospheres – Gas detectors – Performance requirements of detectors for flammable gases* and shall be suitable for the cargoes to be stored in accordance with column 'f' in table of Chapter 19.

13.6.4 For ship units permitted to store non-flammable products, oxygen deficiency monitoring shall be fitted in cargo machinery spaces and cargo tank hold spaces. Furthermore, oxygen deficiency monitoring equipment shall be installed in enclosed or semi-enclosed spaces containing equipment that may cause an oxygen-deficient environment such as nitrogen generators, inert gas generators or nitrogen cycle refrigerant systems.

13.6.5 Permanently installed gas detection shall be of the continuous detection type, capable of immediate response. Where not used to activate safety shutdown functions required by 13.6.7 and Chapter 16, the sampling type detection may be accepted.

13.6.6 When sampling type gas detection equipment is used the following requirements shall be met:

.1 the gas detection equipment shall be capable of continuous monitoring at each sampling head location; and

.2 individual sampling lines from sampling heads to the detection equipment shall be fitted; and

.3 pipe runs from sampling heads shall not be led through non-hazardous spaces except as permitted by 13.6.7.

13.6.7 The gas detection equipment may be located in a non-hazardous space, provided that the detection equipment such as sample piping, sample pumps, solenoids and analysing units are located in a fully enclosed steel cabinet with the door sealed by a gasket. The atmosphere within the enclosure shall be continuously monitored. At gas concentrations of 20 per cent lower

flammable limit (LFL) inside the enclosure an alarm shall be activated in accordance with the requirements of 13.6.11 via the fire and gas system. At gas concentrations above 30 per cent lower flammable limit (LFL) inside the enclosure, the gas detection equipment is to be automatically shut down but the alarm in accordance with 13.6.11 is to be maintained until gas concentrations drop below 20 per cent lower flammable limit (LFL) inside the enclosure.

13.6.8 Where the enclosure cannot be arranged directly on the forward bulkhead, sample pipes shall be of steel or equivalent material and are to be routed on their shortest way. Detachable connections, except for the connection points for isolating valves required in 13.6.9 and analysing units, are not permitted.

13.6.9 When gas sampling equipment is located in non-hazardous space, a flame arrester and a manual isolating valve shall be fitted in each of the gas sampling lines. The isolating valve shall be fitted on the non-hazardous side. Bulkhead penetrations of sample pipes between hazardous and non-hazardous areas shall maintain the integrity of the division penetrated. The exhaust gas shall be discharged to the open air in a non-hazardous location.

13.6.10 In every installation, the number and the positions of detection heads shall be determined with due regard to the size and layout of the compartment, the compositions and densities of the products intended to be carried and the dilution from compartment purging or ventilation and stagnant areas.

13.6.11 Any alarms status within a gas detection system required by this Section shall initiate an audible and visible alarm;

.1 on the navigation bridge (if provided on the installation);

.2 at the relevant control station(s) where continuous monitoring of the gas levels is recorded; and

.3 at the gas detector readout location.

13.6.12 In the case of flammable products, the gas detection equipment provided for hold spaces and interbarrier spaces that are required to be inerted shall be capable of measuring gas concentrations of 0 per cent to 100 per cent by volume.

13.6.13 For membrane containment systems, the primary and secondary insulation spaces are to have independent inert gas systems and independent gas detection systems. The alarm in the secondary insulation space shall be set at 30 per cent of the LFL in air, that in the primary space shall be set at a value approved by LR.

13.6.14 For other spaces described by 13.6.2, alarms are to be activated when the vapour concentration reaches a relatively low per cent LFL (typically 20 per cent of the LFL in air). The fire and gas detection system stipulated by Pt 7, Ch 1,2 shall initiate safety functions required by Chapter 18 and Pt 7, Ch 1,7 if the vapour concentration reaches 60 per cent LFL. However, for gas detection within ventilation ducts, a low level alarm setting of 10 per cent of the LFL in air is to be utilised, due to the potential to generate laminar flow within ductwork. Within turbine hoods and other spaces with potential high air change rates, a low level alarm setting of 10 per cent of the LFL shall be utilised with initiation of emergency shut-down actions if vapour concentrations rates 20 per cent of the LFL. The crankcases of internal combustion engines that can run on gas shall be arranged to alarm before 100 per cent LFL.

13.6.15 Gas detection equipment shall be so designed that it may readily be tested. Testing and calibration shall be carried out at regular intervals. Suitable equipment for this purpose shall be carried on board and be used in accordance with the manufacturer's recommendations. Permanent connections for such test equipment shall be fitted.

13.6.16 Every ship unit shall be provided with at least two sets of portable gas detection equipment that meet the requirement of 13.6.3 or an acceptable national or international Standard.

13.6.17 A suitable instrument for the measurement of oxygen levels in inert atmospheres shall be provided.

13.8 Automation systems

13.8.1 The requirements of this Section shall apply where automation systems are used to provide instrumented control, monitoring/alarm or safety functions required by this Part.

Part 11, Chapter 18

Operating Requirements

18.2 Cargo operations manuals

18.2.1 The ship <u>unit</u> shall be provided with copies of suitably detailed cargo system operating manuals approved by the Administration such that trained personnel can safely operate the <u>unit</u> with due regard to the hazards and properties of the cargoes that are permitted to be carried.

(Part only shown)
18.2.2 The content of the manuals shall include but not be limited to:

.1 Overall operation of the ship <u>unit</u> including procedures for cargo tank cool-down and warm-up, <u>cargo</u> transfer, cargo sampling, gas freeing, ballasting, tank cleaning and changing cargoes;

.2 cargo temperature and pressure control systems;

.3 cargo system limitations, including minimum temperatures (cargo system and inner hull), maximum pressures, <u>cargo</u> transfer rates and filling limits;

18.3 Cargo information

(Part only shown)
18.3.1 Information shall be on board and available to all concerned in the form of a cargo information data sheet(s) giving the necessary data for safe <u>cargo operation</u>. Such information shall include, for each product carried:

.1 a full description of the physical and chemical properties necessary for <u>safe cargo operations</u> and containment of the cargo;

.2 reactivity with other cargoes that are capable of being <u>stored</u>.

18.3.2 The physical data supplied to the <u>Operator</u>, in accordance with 18.3.1.1, shall include information regarding the relative cargo density at various temperatures to enable the calculation of cargo tank filling limits in accordance with the requirements of Chapter 15.

18.4 Suitability for storage

18.4.1 The <u>Operator</u> shall ascertain that the quantity and characteristics of each product to be loaded are within the limits indicated in the Loading and Stability Information booklet provided for in 2.2.5.

18.4.2 Care should be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

.1 tank cleaning procedures required between successive cargoes in the same tank; and

.2 simultaneous storage of cargoes that react when mixed. This shall be permitted only if the complete cargo systems including, but not limited to, cargo pipework, tanks, vent systems and refrigeration systems, are separated as defined in 1.2.<u>44</u>.

18.5 <u>Storage</u> of cargo at low temperature

18.6 Cargo transfer operations

18.6.1 A pre cargo operations meeting shall take place between <u>shuttle tanker</u> personnel and the persons responsible at the transfer facility <u>of the ship unit</u>. Information exchanged shall include the details of the intended cargo transfer operations and emergency procedures. A recognised industry checklist shall be completed for the intended cargo transfer and effective communications shall be maintained throughout the operation.

18.7 Personnel training

18.7.1 Personnel shall be adequately trained in the operational and safety aspects <u>of the unit</u>. As a minimum:

.1 All personnel shall be adequately trained in the use of protective equipment provided on board and have basic training in the procedures, appropriate to their duties, necessary under emergency conditions.

.2 Crew shall be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo and a sufficient number of them shall be instructed and trained in essential first aid for the cargoes carried.

18.8 Entry into enclosed spaces

18.8.3 Personnel entering any space designated as a hazardous area on a ship unit carrying flammable products shall not introduce any potential source of ignition into the space unless it has been certified gas free and is maintained in that condition. Portable gas detection equipment must be utilised at all times to ensure personnel safety.

18.10 Linked emergency shutdown (ESD) system

18.10.2 **ESD valve requirements**

18.10.2.1 **General**

18.10.2.1.2 ESD valves shall be remotely operated, be of the fail closed type (closed on loss of actuating power), shall be capable of local manual closure and have positive indication of the actual valve position. As an alternative to the local manual closing of the ESD valve, a manually operated shut-off valve in series with the ESD valve shall be permitted. The manual valve shall be located adjacent to the ESD valve. Provisions shall be made to handle trapped liquid should the ESD valve close while the manual valve is also closed.
A manually operated vent valve in the pneumatic/hydraulic logic is preferable to an additional in-line valve.

(Part only shown)
18.10.2.1.4 The closing time of the valve referred to in 13.3.1 to 13.3.3 (i.e., time from shut-down signal initiation to complete valve closure) shall not be greater than:

LR = maximum loading rate agreed between ship unit and shuttle tanker (m^3/h).

The loading rate shall be adjusted to limit surge pressure on valve closure to an acceptable level, taking into account the loading hose or arm and the piping systems of the ship unit and shuttle tanker where relevant.

18.10.2.2 **Ship unit-shuttle tanker manifold connections**
One ESD valve shall be provided at each manifold connection. Cargo manifold connections not being used for transfer operations shall be blanked with blank flanges rated for the design pressure of the pipeline system.

18.12 Additional operating requirements

Additional operating requirements will be found in the following paragraphs of this Part 2.2.2, 2.2.5, 2.2.6, 3.8.3, 3.8.4, 5.3.2, 5.3.3.3, 5.7.3, 7.1, 8.2.7, 8.2.8, 8.2.9, 9.2, 9.3, 9.4.4, 12.1.1, 13.1.3, 13.3.5, 13.6.16, 14.3.3, 15.3, 15.6, 16.6.3.

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